Final Public Report ESA-117

1. Introduction:

This plant produces emulsions, plastic additives, monomers, paraloids and acryloids. Processing includes product production in batch reactors, drying and distillation. Process heat is provided by direct-fired natural gas heating and by superheated steam (400 psig, 600^{o}F) in two 180,000 lb/hr. boilers. High-pressure, superheated steam was previously used to operate backpressure turbines all of which have been removed from service. About 1/3 of produced high pressure steam is sold to an adjacent plant. The remaining supply is reduced to 150 psig and 75 psig for process heating use. Boiler fuels include production waste material and natural gas (2005 breakdown: 42%, 58% on an energy basis). The most substantial steam use is in a methylmethacrylate distillation system and in one product dryer. An additional three dryers are direct-fired with natural gas.

2. Objective of ESA:

The objective of this ESA was twofold:
a) To train company/plant personnel in the use of the DOE Steam Tool software.
b) To perform a "training assessment" of plant equipment and processes leading to the recommendation of measures for achieving substantial plant energy savings.

3. Focus for Assessment:

The ESA focused on the plant-wide use of steam with an emphasis on the reduction in steam consumption and cost. The steam-saving projects considered were discussed and evaluated in terms of the parallel requirement of maintaining environmental emissions within permit limits while burning waste and natural gas in the main steam-generating boiler. Issues of typical boiler steam load variations and effect on emissions were considered.

4. Approach for ESA:

The ESA Expert worked directly and continuously on-site with the Plant Lead (Holthouser), the Utilities Team Leader (Berry) and a Corporate Project Manager (Kinsley). During initial discussions, it was learned that a plant team has been considering energy-saving projects for several years as a part of an on-going company-wide initiative to control costs. A list of 19 measures developed prior to the ESA and the SSAT project list were used together to derive a list of twelve proposed projects for further consideration as part of the ESA. In evaluating measures initially deemed technically feasible, the Expert demonstrated the use of SSAT for simulating steam system performance. Technical data needed to evaluate the proposed measures were obtained from plant records or in discussions with plant personnel having knowledge of specific plant operations. The Expert and the participating plant and company personnel then used SSAT to evaluate the proposed projects to arrive at a final set of six recommendations.

5. General Observations of Potential Opportunities:

a) Purchased energy annual consumption and cost:

Natural Gas
Consumption (2005 Purchases): 876,000 MMBtu./yr.
Cost: $8,956,000 ($10.22/10^6 BTU)

Electricity
Consumption (2005): 97,900,000 kWh/yr.
Cost: $4,000,000 ($0.035/kWh)

b) SSST Results:

Steam system profiling: 71/90 pts. = 79% (DOE database plants: 59%)
Steam system operating practices: 90/140 pts. = 64% (DOE database plants: 74%)
Boiler plant operating practices: 65/80 pts. = 81% (DOE database plants: 62%)
Distribution, end use, recovery and operating practices: 16/30 pts. = 53% (DOE database plants: 54%)
Overall score: 242/340 pts. = 71% (DOE database plants: 66%)

6. Energy Saving Opportunities:

1. Change boiler efficiency (SSAT Project #3); Install a condensing economizer on Boiler 100:

Currently, the operated dual-fuel (production waste and natural gas) boiler is equipped with an economizer for feedwater heating. The heat exchanger exit gas temperature of about 370^{o}F indicates that all latent heat of fuel combustion is currently lost to the atmosphere. Installation of a condensing economizer would provide further feedwater heating and the pre-heating of process reactor water. The potential for acid condensate corrosion of heat exchanger and stack surfaces must be thoroughly investigated and mitigated before implementing this measure. (**Medium-term opportunity;** potential natural gas saving: 4.0%)

2. Change steam generation conditions (SSAT 6); Reduce steam pressure moderately:

   Although currently no turbines are in use, superheated steam at the original system design conditions (400 psig and 600^{o}F) is still produced in the two utilized boilers. For process use, steam is pressure-reduced to 150 psig and 75 psig. Since both a steam-purchasing customer (about 1/3 of steam produced) and plant processes can operate on steam at a lower pressure and temperature, consideration should be given to a modest reduction in boiler output pressure. The plant currently allows steam pressure to vary moderately as plant loads change during batch production. Risks of water carry-over into the superheater section of the boiler must be fully evaluated before implementing this measure. The boiler manufacturer should be consulted for guidance. (**Near-term opportunity**; potential natural gas savings: 2.0%)

3. Condensate return (SSAT #13) Increase condensate return:

   Since there is no direct steam contact heating, all plant processes using steam generate condensate. The plant was designed with no condensate return. Recently, a system was installed on a select process equipment to return about 37% of condensate produced. This system is currently undergoing refinement to achieve design operational performance. The addition of condensate return from Building 14 (Reactors A - H) would allow an additional 11% condensate return. (**Medium-term opportunity**; potential natural gas savings: 0.5%)

4. Change boiler efficiency (SSAT #3); Program boiler management system to display instantaneous efficiency to guide operator minimization of excess air:

   Currently, both utilized boilers are thoroughly instrumented to allow monitoring of steam production and stack gas conditions including regulated emissions. Boiler operators use these data to respond to (sometimes abrupt) changes in steam demand due to batch production operations. The need to maintain under-threshold environmental emissions precludes the use of automatic O_2 trim control systems. A modest efficiency improvement can be achieved by developing code to compute real-time efficiency to guide operators in the continuous minimization of excess air. (**Near-term opportunity**; potential natural gas savings: 0.4%)

5. Change boiler blowdown rate (SSAT #4); Add reverse osmosis capacity to improve boiler water quality and reduce blowdown:

   Boiler make-up water obtained from a nearby river is conditioned by filtration and softening before deaeration. With this limited treatment, an average blowdown rate of 12% is needed to prevent waterside fouling. Meanwhile, an existing reverse-osmosis water treatment system is used to provide process water for batch reactors. Adding capacity to this existing system for boiler feedwater treatment will allow a substantial reduction in blowdown requirement to an estimated 2%. Cleaner boiler water will aid in reducing boiler and steam system maintenance which will in turn reduce the effective payback for this measure beyond that for the energy-saving benefit alone. (**Near-term opportunity**; potential ARP natural gas savings: 0.2%)

6. Steam demand savings (SSAT #1) Valve-off steam supply to unused and lightly-used equipment:

   Two steam distribution lines were identified which deliver steam to unused or minimal-use downstream equipment: a main to the west-end of the plant and a line to an unused steam turbine. Valving-off these lines will save a modest amount of standby energy loss. All steam-users downstream must be carefully assessed and the use of electric heat for occasional use equipment may be required. (**Near-term opportunity**; potential natural gas savings: 0.1%)

   Summary of potential savings:

   Near-term measures: 23,499 x 10^6 Btu/yr.
   Medium-term measures: 43,921 x 10^6 Btu/yr.
   Long-term measures: 0 x 10^6 Btu/yr.

7. Management Support and Comments:

   Company and plant managers arranged for the Plant Lead (Holthouser), the Utilities Team Leader (Berry) and a Corporate Project Manager (Kinsley) to work continuously with the ESA Expert over a three-day period to clarify plant operations and concerns and to assist in the formulation of energy-saving measures for further consideration. Additionally, several plant process operators provided information to clarify plant procedures and to supply data needed for project analysis. Plant management personnel were very supportive of the ESA and rated the value of the assessment as substantially useful in guiding energy conservation and associated cost reduction actions.

8. DOE Contacts at plant/company

   Plant Contact:

   Robert Holthouser, ESA Plant Lead, (Points of contact listed above)